# Negative extinction in one-dimensional scattering

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It has recently been shown [1] that negative extinction can occur for scattering of an electromagnetic plane wave by a dielectric spherical particle in an absorbing medium. This result can be interpreted as more energy per second leaving the scattering volume than enters it. The same effect is shown to occur when an electromagnetic plane wave in an absorbing medium is normally incident on a plane-parallel dielectric slab. This one-dimensional geometry has the advantages that the scattered wave consists only of transmission and reflection, and that it is exactly analytically soluble. The transmitted plus reflected fraction of the incident energy per second exceeds 100% for certain slab thicknesses. This is because the phase of a wave reflected at an interface between dielectric and absorbing materials is shifted from its value for reflection at an interface between two dielectric materials. This leads to the maxima and minima of the composite reflected intensity being phase shifted with respect to the minima and maxima of the composite transmitted intensity, thus causing the illusion of excess energy. The amount by which energy conservation is seemingly violated is exactly compensated by the contribution to the Poynting vector describing incident/reflected wave interference. This contribution vanishes when the medium is dielectric, and is nonzero only when the medium is absorbing. It results from the phase shift of the magnetic field of the waves in the absorbing medium with respect to their electric field.

## References

[1] Mishchenko, M. I., G. Videen, and P. Yang, 2017: Extinction by a homogeneous spherical particle in an absorbing medium. *Opt. Lett.* **42**, 4873–6.

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